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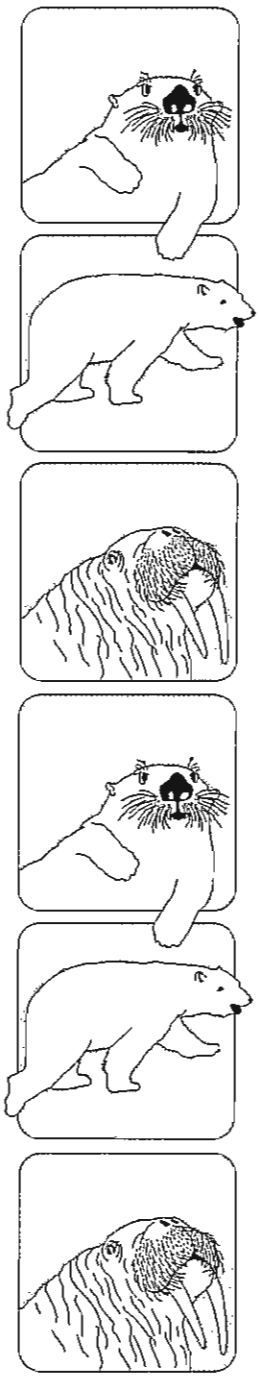

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BY

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ABSTRACT

The U.S. Fish and Wildlife Service conducted an aerial survey of sea otters (*Enhydra lutris*) in the Aleutian Islands in April 1992. The survey consisted of a shoreline survey around each island, 60 ground-truthing segments on Amchitka and Adak Islands, and 72 offshore transects that extended perpendicular from the shoreline out to the 50 fathom isobath. During the shoreline survey the aircraft was flown approximately 0.23 km from shore. Two observers, one on each side of the aircraft, recorded the sea otter sighting number, group size, and distance interval of each sighting from the aircraft.

Sea otters were observed on all but 12 islands, with 3,837 sightings totaling 8,026 individuals. A correction factor for otters missed from the aircraft, calculated from simultaneous aerial/ground counts, was 2.38 (SE=0.208). Based on this correction factor, the adjusted population estimate was 19,104 $\pm$ 3,272. The population estimate for the offshore area in the Aleutians between the 0.9 km and the 50 fathom isobath was 463 $\pm$ 377 sea otters. Significantly more sea otters were seen within 200m of shore than at greater distances. Sea otters were seen in groups of one or two 58% and 22% of the time, respectively.

The Aleutian population was estimated at 55,100 in 1985, based on a numerical expansion of data collected prior to 1976 at Amchitka, Kanaga, and Tanaga Islands (Calkins and Schneider 1985). The discrepancy between the two estimates may have resulted from fewer sea otters in 1992, an over estimate of abundance in 1985, or an underestimate of abundance during this survey. We documented large scale changes in the abundance and distribution of sea otters in the Aleutians over the past three decades based on comparisons between Kenyon's 1965 and the Fish and Wildlife's 1992 aerial surveys.

Key words: Aleutian Islands, population, sea otter, *Enhydra lutris*, aerial survey

INTRODUCTION

Between the mid-1700s and the late 1800s sea otters (*Enhydra lutris*) in Alaska were hunted almost to extinction. Kenyon (1969) identified two remnant populations in the Aleutians that survived commercial hunting. These small populations formed the nucleus for recolonization after sea otters received protection from commercial exploitation in 1911. In the absence of large-scale exploitation, sea otters have since increased in number and now reoccupy most of their historic range in Alaska (Rotterman and Simon-Jackson 1988). Calkins and Schneider (1985), using data collected through 1976, estimated that over 50 percent of the Alaska population of sea otters reside in the Aleutian Islands. Information collected on sea otter

abundance and distribution for the Alaska Peninsula, Kodiak Island, Prince William Sound, and southeast Alaska is current (within the last 10 years) (Brueggeman et al. 1987, Simon-Jackson and Hodges 1987, Monnett and Rotterman 1989, Pitcher 1989, DeGange et al. 1990, Burn 1994, Agler et al. 1995, Doroff 1997) however the Aleutians, because of their remoteness, have not been surveyed in their entirety since 1965 (Kenyon 1969). To evaluate potential change in the abundance and distribution of sea otters in the Aleutian Islands since 1965, the U.S. Fish and Wildlife Service, conducted an aerial survey during April 1992.

METHODS

Study Area

The Aleutian Islands, west of Unimak Pass (between 172°E and 164°W longitude and 50°N and 55°N latitude) form part of the boundary between the Bering Sea and the North Pacific Ocean. The survey area consisted of six island groups containing 78 major islands with approximately 4528 km of coastline (Figure 1). Sea otter habitat types most commonly encountered within the sampled shoreline area consisted of exposed rocky coasts, deep fjords, and shallow bays. Although sea otters have been known to feed at depths of 97 m (Newby 1975) they usually rest and feed in water less than 40 m (Estes 1980). The amount of available sea otter habitat within the 10, 30, and 50 fathom isobaths is limited on many islands due to typically steep bathymetric contours.

Survey Design

The survey aircraft was a de Havilland turbine Twin Otter, Series 300, equipped with two large bubble windows, long range fuel tanks, and room for 4 observers. The survey crew consisted of the pilot, co-pilot, two observers, and a computer operator. The seats with bubble windows were located on opposite sides of the plane directly aft of the cockpit. The observers, one on the shoreline side and the other on the offshore side of the plane, counted sea otters, and relayed the information to the computer operator.

The plane flew approximately 0.23 km from shore at an altitude of 91 m, with an airspeed of approximately 185 km/hr. The survey area was divided into a coastal zone that included all waters between shore and 0.69 km from shore and an offshore zone that included all waters offshore of 0.9 km. Originally we had planned to fly at a distance 0.46 km from the shore but after the initial survey realized that fewer sea otters would be missed if we flew 0.23 km from the shore. The changes in the survey design resulted in a strip between 0.69 km and 0.9 km that was not surveyed. Approximately 99% of the coastal zone of all major islands, from Unimak Pass to

Attu, was surveyed. Small offshore rocks and islands which occurred at distances greater than 0.9 km from the main shoreline were treated as coastal areas and surveyed. Due to adverse weather conditions, small sections of a few islands were not surveyed.

To determine the approximate distances of sea otters from shore, the observers noted the distance interval from the aircraft of each otter group. Distance intervals, corresponding to 0.115 km strips, were estimated using marks placed on the bubble windows. These marks were observer-specific and checked frequently for accuracy using a clinometer. Bubble windows allowed for perpendicular viewing below the center of the plane. To minimize observer fatigue, each member of the survey crew took turns observing and entering data. In general, observers rotated positions every hour. Sighting number, group size, and distance interval were recorded on data forms, and location, altitude, weather, visibility, and observer identification were recorded directly into a Zenith 286 laptop computer (Zenith Electronics Corporation, Glenview, Illinois) interfaced with a global positioning system (GPS). The computer automatically queried the navigation system at one minute intervals. A portable tape recorder and a Kodak Diconix 150 Plus ink jet printer were used for backup and verification.

A Geographical Information System (GIS) was developed of the shoreline, bathymetry, sea otter locations, and survey flight paths. The sea otter locations and survey flight paths were created using the GPS coordinates during the survey and the bathymetric coverages were digitized from 1:250,000 nautical charts. The shoreline and offshore sampling area, sea otter distribution, estimates of survey effort in kilometers flown, and location of sea otters with respect to distance from shore and bathymetry were determined using information from the Arc/Info coverages. We examined differences in sea otter numbers observed relative the distance from shore using a Kruskal-Wallis one-way analysis of variance (ANOVA).

In addition to counts within the coastal survey zone, sea otters were surveyed on 70 randomly selected offshore line transects as the transects were encountered. Initially 210 offshore transects were randomly selected from 416 previously mapped and digitized offshore transects. The cut off point used to select these transects was 1,200 km, which was approximately 25% of the estimated shoreline length. However surveying the initial set of offshore transects in addition to the shoreline survey proved to be too stressful for the pilots and compromised the chances of completing the study so the number of offshore transects randomly selected was reduced to 70. The offshore transects were flown using GPS way points. The offshore transects were located at least five kilometers apart, to prevent otters from being counted twice on adjacent transects and when possible made use of prominent landmarks

for ease of visual identification from the air. The offshore transects started 0.9 km from the shoreline and extended perpendicular to the shoreline out to the 50 fathom isobath.

Ground Truthing

Estes (1977) estimated that at any one time, 30% of the otters are underwater and unavailable for counting during aerial surveys. Therefore, a correction factor based on simultaneous air and ground counts was developed during this study to correct our population estimates. We selected five coastal segments where otters were known to be present and with good accessibility and visibility at Amchitka and Adak for the ground counts. Ground crews consisted of 3-5 observers, one per ground-truth segment. Each member of the ground crew recorded and mapped all otters seen within their ground-truth segment. Counts of sea otters made by the ground crew on both the outgoing and return trips, were averaged and represented the number of sea otters along that segment. Because it took 4-6 hours to complete the ground truth segments we conducted three aerial counts simultaneously to ground counts at both Amchitka and Adak on two consecutive days. This resulted in 30 (3 flights x 5 segments x 2 days) aerial/ground comparisons for each island. The observers switched positions in the plane between each replicate. To compare these areas with the most reliable aerial counts, only those otters within 0.46 km of the coast were used in calculating the correction factor.

The correction factor for each segment was determined by dividing each aerial count by the average ground count for each of the 10 ground truth segments, which were equally allocated between Adak and Amchitka. The overall sighting probability for Adak and Amchitka was averaged and then compared using a t-test.

Population Estimation

Geographical Information System coverages were used to determine the sampling area for density estimates and to map the distribution of sea otters within the study area. While flying approximately 0.23 km from the shore there were two distance intervals on the shoreline side and four distance intervals on the pelagic side of the plane. Since detection probability rapidly declines at distances >400 m (Bodkin and Udevitz 1996) we used a 0.46 km buffer in our calculations of sea otter density and used 0.69 km for the population estimates. The density estimates, which provide an index to density, allow for comparisons between islands and island groups. The population estimates presented are based on "complete" counts, which means that the entire coastal segment was observable. Therefore, the variance associated with the population estimates is derived solely from the variation in development of the correction factor from the simultaneous air and ground counts.

Densities from the line transects for the offshore area, between the outer edge of the coastal strip (0.9 km) and the 50 fathom isobath, were calculated using the Distance Program Version 2.0 (Laake et al. 1993). Since the offshore coverage was limited, offshore estimates were not included in the table for each island/island group.

RESULTS

A total of 118 hours of aerial survey were flown on 14 days between 1 April 1992 and 30 April 1992. We surveyed in April because it contained the highest number of expected favorable weather days, based on an analysis of weather data from 1986-1990 at two of our bases of operation, Adak and Dutch Harbor. Aerial surveys were flown only when there was > 8 kilometers visibility, ceiling was > 457 m, and wind speeds were < 24 kmph. Overall, weather conditions during the survey were good to excellent. Approximately 94% of the observations were made when winds were less than 11 kmph as determined by the Beaufort Sea State.

Abundance

A total of 5,480 km was flown during the shoreline survey with 3,874 sea otter sightings totaling 8,048 individuals. The proportion of sea otters sighted from aerial/ground counts at Adak (0.4804) and Amchitka (0.4023), was not significantly different ($t=0.94$, $df=52$, $p=.176$). Therefore the aerial/ground counts were pooled to produce an overall sighting proportion of 0.42, which corresponds to a correction factor of 2.38 (SE=0.208). The adjusted population estimate for the entire survey area, based on the 60 simultaneous air/ground counts, was 19,157. Population estimates based on numerical expansion, to account for the one percent of the shoreline that was not surveyed, increased the overall sea otter population estimate by 192 to 19,349. Summary statistics of area sampled, actual counts of sea otters, estimated populations with 95% confidence intervals, and sea otter densities within 0.69 km. of shore are presented in Table 1.

Significantly more sea otters were seen within 0.12 km of shore than at greater distances ($X^2=25.1$, $df=4$, $P < .0001$)(Figure 2). Sea otters were seen in groups of one or two 58% and 22% of the time, respectively (Figure 3).

Sea otter densities were greatest in the Near Islands and Rat Islands, in the western Aleutians, and lowest in the Fox Islands and Islands of the Four Mountains. There was much greater variation in densities of sea otters among individual islands in the Rat Islands, Delarof Islands, and Andreanof Islands than in the other groups. Even though the total sampled area in the Fox Islands, in the eastern Aleutians, was similar to the total area sampled in the Delarof and Andreanof Islands, the sea otter density was much lower (Table 1).

Only 25 sightings of sea otters, totaling 29 individuals, occurred on the offshore transects. Although the number of sightings was < 40, the minimum recommended by Burnham et al. (1980) for line transect sampling, we calculated an offshore density as 0.27 otters/km^2. The population estimate for the offshore area throughout the Aleutians was 463 $\pm$ 377 sea otters.

Distribution

Sea otters were observed in the waters surrounding all islands, except for 12 of the smaller islands, most of which, occurred in the Fox Islands (Table 1). Overall, sea otters were fairly evenly distributed along the shoreline of most islands. Larger groups of sea otters were often found in bays, fjords, narrow passages between islands, and other protected areas. No otters were seen hauled out on land. Large concentrations of 100 or more sea otters were observed twice on Attu, and once on Amchitka, Adak, Atka, and Unalaska Islands.

The Near Islands - The overall density within 0.46 km from the shore of sea otters in the Near Islands, the westernmost group of islands in the Aleutians, was 11.53 otters/km^2. Sea otters were found throughout the nearshore coastal habitat at Attu (Figure 4). Except for one otter found on an offshore transect between the 30 and 50 fathom isobaths, all otters at Attu were concentrated along the nearshore coastal habitat at depths < 30 fathoms. The largest concentrations on Attu were in Massacre Bay, between Holtz and Sarana Bay, Stellar Cove, and the shoreline northeast of Stellar Bay between Austin Cove and Kresta Point. Sea otters were fairly evenly distributed along the coast of Agattu. Within the Semichi Islands, sea otters were concentrated around Nizki Island and the southwest shore of Shemya Island.

The Rat Islands (including Buldir Island) - Densities of sea otters were highest at Amchitka, Kiska, and Little Kiska Islands. Little Kiska Island had 25.65 otters/km^2, which was the highest density recorded during the survey. At Amchitka Island, 81% of the sea otters were seen on the northeast shoreline. On Kiska Island, most of the sea otters were located on the southwest coast, and on Buldir Island, sea otters were found primarily in the shoals adjacent to Northwest Point (Figure 5).

The Delarof and Andreanof Islands - The highest densities of sea otters in the Delarof Islands were found at Ilak, Kavalga, and Oluiga/Skagul Islands. Most of the otters were fairly evenly distributed along coastal areas in the Delarof Islands with the exception of Amatignak and Kanaga Islands (Figure 6). Sea otters were found primarily in the area around Knob Point on Amatignak Island, and on Kanaga Island, 61% of the otters occurred along the southern shore.

Within the Andreanof Islands, sea otter densities were greatest on Aziak, Tanaklak, Kanu and Adak Islands. Adak, Atka, and Amila Islands accounted for 83% of the sea otters seen in the Andreanof Islands. At Adak sea otters were found in greater numbers in Kuluk Bay, Shagak Bay, Bay of Islands, and the shoreline west of Cape Adagdak. Very few otters were seen on Little Tanaga Island and most of those were located along the eastern shoreline. At Atka the greatest numbers of sea otters were seen in Korovin Bay, the west shoreline of Nazan Bay, and the coastal area from Cape Tadluk to Vasilief Bay.

Islands of Four Mountains - Sea otters were observed on all the islands except Chagulak Island, which was not surveyed because of unsafe flying conditions due to a large colony of Northern Fulmars (*Fulmaris glacialis*)(Figure 7). Fewer sea otters were seen in the Islands of Four Mountains than in any of the island groups in the Aleutians.

Fox Islands - Sea otter densities in the Fox Islands were greatest on Akun, Sedanka, and Samalga/Umnak islands. Although Unalaska Island has twice the amount of shoreline as Samalga and Umnak islands, which are located 10 kilometers to the west, Unalaska Island had approximately the same number of total otters (Figure 8). Sea otters on Unalaska Island were concentrated in two main areas, the southwest coastal area from Makushin Bay to Lion Bight and the Beaver Inlet/ Sedanka Island area in the southeast.

DISCUSSION

Based on the conclusions of Calkins and Schneider (1985)in which they estimated a population of sea otters in the Aleutian Islands of between 55,000 and 73,000, we expected to observe a greater abundance of sea otters than we did. The disparity between out estimate and those of Calkins and Schneider (1985) suggests one or a combination of the following: the population has declined; we underestimated the size of the population; or Calkins and Schneider's overestimated the size of the population.

If uncorrected for sighting probability, aerial surveys of sea otters typically underestimate the population. Evidence for this comes from the fact that boat and ground counts usually exceed aerial counts over the same area (Estes and Jameson 1988, Udevitz et al. 1990). Pups, because of their small size and close association to their mothers are often not counted from the air. In addition, foraging sea otters are underwater and may be missed as the aircraft passes quickly overhead, and resting and hauled-out otters may be difficult to identify in dense kelp beds or on land. We believe our survey methodology and correction factor resulted in reasonable estimates of sea otters for most of the islands in the Aleutian chain. We were

continually impressed throughout the survey with how few sea otters we counted around some islands. However there is some evidence that we underestimated the sea otter population in some areas, notably Amchitka Island. At Amchitka Island, sea otters are particularly dense (Estes 1990) and can be distributed far offshore on calm days. When we surveyed Amchitka Island, there were strong southwesterly winds and very rough water on the windward side of the island. Few sea otters were likely offshore on the southwest side of the island. Only two otters were seen on six offshore transects surveyed on the southwest side of the island. No otters were seen on the one offshore transect surveyed on the northeast side of the island. A ground-based survey in 1993 of sea otters at Amchitka suggests that the actual sea otter population may be more than twice our estimate (Estes, unpubl. data)

One advantage of our survey, where we achieved nearly complete coverage of the Aleutian chain, is that error associated with using representative densities to calculate population estimates did not occur. In our study, densities of sea otters on islands varied from zero to 25.65 otters/km^2. We believe Calkins and Schneider's (1985) population estimate for the Aleutian Islands may have overestimated the true population at the time because it was based on an extrapolation of surveys from a few islands where densities may have been unrepresentatively high for the entire Aleutian chain. Our observations suggest that with a number of exceptions, the waters surrounding the Aleutian Islands have a steep bathymetric gradient, and generally are not able to support high densities of sea otters.

Although a number of sea otter surveys have been done in the Aleutians (Kenyon 1969, Estes 1977, Day et al. 1979, Calkins and Schneider 1985, Brueggeman et al. 1987, Estes 1990, Evans 1992, Meehan et al. 1996, Estes and Tinker 1996) only one is directly comparable to our survey because of differences in the area surveyed, survey effort, methodology, and sampling design. The 1965 survey conducted by Kenyon (1969) was most similar to ours and allows for large-scale comparisons of sea otter distribution and abundance over nearly a 3-decade period. Kenyon (1969) conducted his survey from a DC-3 airplane with observers stationed behind the pilot and co-pilot seats. Kenyon (1969) used a sliding correction factor that varied from 50-75 percent and applied it based on the size of the observed group of sea otters. Even Kenyon's highest correction factor (2.0) is lower that the correction factor than we used. Because we believe the DC-3 was a cumbersome platform for surveying sea otters compared to the twin otter used in our survey and because Kenyon's correction factor is less than ours, we believe Kenyon's survey may have underestimated sea otter populations in 1965. Assuming that our estimates are reasonable for most islands in the chain, then evidence of population changes for island groups derived from a comparison of Kenyon's and our surveys would be stronger than indicated for population declines.

Table 2 compares Kenyon's and our surveys by island and island group. These comparisons suggests that populations have declined throughout the Rat, Dealarof, and western Andreanof islands. On the average counts from the 1992 aerial survey are 50-60% lower than Kenyon's and in several cases exceed 90%. Only 4 of the 27 islands for which comparisons are available showed an increase. In addition, recent survey data from the central Aleutians suggests that sea otters are undergoing a population decline (Estes 1996). There is evidence that populations in the Rat Islands, particularly at Amchitka Island, where numerous sea otter surveys have been conducted, have undergone fluctuations during the past 30 years. These population fluctuations suggest that sea otters probably occupy all the available habitat and populations are in equilibrium with the habitat (Estes 1990). Similar population increases and declines on Kiska Island, Rat Island and Semisopochnoi Island (Kenyon 1969, Day et al. 1979, Maminov 1991, Estes pers. comm.) suggest that these populations may also be in equilibrium with the habitat.

In contrast to the Rat, Delarof and western Andreanof Islands, populations in the Near Islands, eastern Andreanof, and Fox Islands have steadily increased since 1965. Unlike the situation in the Rat Islands, where sea otter populations are probably limited by density dependent factors such as the amount of available habitat and food (Estes 1990), sea otter populations in the Near Islands (Estes 1990) and the Fox Islands (Schneider and Faro 1969, Nysewander 1982, Brueggeman et al. 1987) probably have not reached carrying capacity and likely have the potential to increase through range expansion.

Estimates of total population from partial counts using ratio estimation techniques (Cochran 1977) or numerical expansion may overestimate or underestimate the true population if the densities in the areas surveyed are not representative of the areas not surveyed. Some examples where partial surveys were used to estimate abundance include partial aerial and boat surveys during the summer of 1990 and 1991. For example in 1986, 1,600 sea otters were counted during a boat survey of the entire coastline of Attu Island (Estes 1990). Assuming an annual rate of increase of 17% (Estes 1990), then approximately 4,104 sea otters would be expected in 1992. Evans (1991, 1992) estimated the sea otter population based on partial aerial and boat counts to range from 3,391 to 4,980. These estimates were based on the assumption that the density of sea otters counted in segments with complete counts was representative of segments not counted. However, results from the 1992 survey indicate that although otters were found throughout the nearshore habitat, they were not evenly distributed. The distribution of otters within a particular area seems to be closely correlated to the distribution of available feeding habitat (Kenyon 1969, VanBlaricom and Estes 1988). Therefore, population estimates from incomplete counts may be misleading because sea otters often occur in a clumped distributions which may be associated with the variability in the amount of available or preferred feeding habitat and protected areas for resting (Kenyon 1969).

Based on this survey the Aleutians contain approximately 21% of the Alaskan sea otter population (USFWS 1994). Although the total number of otters seen in this survey was similar to that reported by Kenyon in 1965 (Kenyon 1969), the distribution has changed. The most notable changes in the abundance and distribution were in the eastern Andreanof Islands and the Fox Islands. Although sea otter densities were greater in the Near and Rat Islands, in the western Aleutians, sea otters were most abundant in the Delarof and Andreanof Islands in the central Aleutians. If benthic invertebrates and coastal fishes, the principle prey of sea otters, are as abundant in the eastern Aleutians as in the western Aleutians, then we would expect increases in sea otter numbers in the Fox Islands.

At this time the populations of sea otters in the Aleutians remain largely free from human disturbances. Less than 2% of the sea otters taken in Alaska are harvested in the Aleutians (Stephensen et al. 1994). Due to the remoteness from major human population centers it was assumed that the Aleutians were relatively pristine, however, the presence of high levels of total PCB at Adak, whether from local sources or via long range transport through ocean or atmospheric currents, is of concern (Bacon 1994, Estes et al. 1997).

Despite sources of variability, aerial surveys of the entire Aleutian Islands, such as our 1992 survey and Kenyon's 1965 survey, provide a practical means to monitor large scale trends in abundance in this remote area. We believe that aerial surveys with a rigorous, repeatable survey design, are comparable and can provide an index to large scale changes in abundance and distribution. If bias between aerial surveys is consistent then they provide a valuable management tool for surveying sea otter populations in the Aleutian Archipelago.

It is unlikely that sampling a proportion of the available habitat each year would allow managers to detect large scale changes with respect to the population abundance and distribution in the Aleutian Archipelago. The patchy distribution of sea otters, variability in the status of local sea otter populations with respect to the carrying capacity of the environment, habitat differences, and the ability of large numbers of sea otters to move relatively long distances (~100km) yearly to colonize new areas are some of the factors that support the use of "complete" versus partial surveys .

Frequent aerial surveys of sea otters in the entire Aleutian chain are unlikely to occur because of the logistics and expense of conducting surveys in this relatively large and remote area. However, information from these periodic surveys may be useful in delineating specific area(s) for more intensive study. To assess population changes on a smaller scale (i.e. between islands) more accurate sea otter counts are required. Boat based surveys of the entire coastal area of the sampling area, are currently the most accurate and practical survey method available for most of the

Aleutian Islands. Population surveys, which include repeated counts on smaller areas, such as individual islands or island groups, coupled with other studies to assess habitat and resource quality and availability, could potentially provide insight into the natural fluctuations in sea populations with respect to their environment and allow for a more accurate assessment of large scale ecosystem changes. Aerial surveys can be used in the future to monitor trends in abundance and continue to have potential value considering the decline of marine species elsewhere in the North Pacific.

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Table 1. Estimated number of sea otters in the Aleutian Islands. Corrected counts are obtained by multiplying the actual count by the sightability correction factor of 2.38. Population and density estimates based on a 0.69 km and 0.46 km buffer from the shoreline, respectively.

Island Group/ Island Name	Sampled Area (km^2)	Actual Count	Corrected Count	95% c.i.	Density (Otters/km^2)
Near Islands					
Attu	120.30	636	1,514	± 259	12.47
Agattu	50.55	216	514	± 88	10.17
Alaid/Nizki	14.60	54	129	± 22	8.80
Shemya	10.46	49	117	± 20	11.15
Subtotal	**195.91**	**955**	**2,273**	**± 389**	**11.53[a]**
Rat Islands					
Buldir	12.29	11	26	± 4	2.13
Kiska	77.64	350	833	± 143	10.73
Little Kiska	9.84	106	252	± 43	25.65
Segula	12.46	19	45	± 8	3.63
Khvostof	4.10	13	31	± 5	7.55
Davidof	7.84	28	67	± 11	8.50
Little Sitkin	18.44	38	90	± 15	4.91
Rat	16.63	79	188	± 32	11.31
Amchitka (4/25/92)	95.39	755	1,797	± 308	18.76
Amchitka (4/27/92)	95.39	711	1,692	± 290	17.44
Semisopochnoi	31.36	62	148	± 25	4.71
Subtotal[b]	**285.98**	**1,461**	**3,478**	**± 596**	**12.14[a]**
Delarof and Andreanof Islands					
Amatignak	13.46	16	38	± 7	2.83
Ulak	17.51	36	86	± 15	4.89
Unalga	5.93	6	14	± 2	2.41
Kavalga	12.41	95	226	± 39	18.23
Oluiga/Skagul	23.02	123	293	± 50	12.72
Ugidak/Tag Islands	1.2	0	0		0.00
Ilak	4.99	40	95	± 16	19.10
Gareloi	15.90	19	45	± 8	2.84
Tanaga	95.00	317	755	± 129	7.94
Bobrof	6.60	10	24	± 4	3.61
Kanaga	84.61	333	793	± 136	9.37
Adak	178.60	1,045	2,487	± 426	13.90
Kagalaska	36.04	157	374	± 64	10.37
Little Tanaga	43.30	38	90	± 15	2.09
Umak	19.84	38	90	± 15	4.56
Anagaksik	2.61	1	2	± 0	0.91
Great Sitkin	33.09	72	171	± 29	5.18
Ulak	2.52	0	0		0.00

Table 1. continued.

Island Group/ Island Name	Sampled Area (km²)	Actual Count	Corrected Count	95% c.i.	Density (Otters/km²)
Aziak	3.13	17	40	± 7	12.94
Tanaklak	4.77	25	60	± 10	12.48
Kanu	4.72	42	100	± 17	21.18
Asuksak	2.87	7	17	± 3	5.80
Tagadak	3.78	7	17	± 3	4.41
Igitkin	13.66	36	86	± 15	6.27
Chugul	11.55	23	55	± 9	4.74
Tagalak	15.75	19	45	± 8	2.87
Ikiginak	3.18	0	0		0.00
Oglodak	4.04	3	7	± 1	1.77
Kasatochi	4.69	5	12	± 2	2.54
Koniuji	2.68	0	0		0.00
Atka	242.15	1,119	2,664	± 455	10.97
Segchudak	3.88	7	17	± 3	4.29
Sadatanak	2.87	2	5	± 1	1.66
Amtagis	1.51	0	0		0.00
Salt	3.48	9	21	± 4	6.15
Amlia	125.11	425	1,012	± 173	8.09
Seguam	32.42	10	24	± 4	0.73
Subtotal	**1081.66**	**4,102**	**9,764**	**± 1,672**	**9.02[a]**
Islands of Four Mountains					
Amukta	14.71	1	2	± 0	0.16
Chagulak	6.65	0	0		0.00
Yunaska	30.78	6	14	± 2	0.46
Herbert	15.41	13	31	± 5	2.01
Chuginadak	38.97	33	79	± 13	2.02
Carlisle	13.33	11	26	± 4	1.96
Kagamil	14.10	7	17	± 3	1.18
Uliaga	6.88	1	2	± 0	0.35
Subtotal	**140.84**	**72**	**171**	**± 29**	**1.22[a]**
Fox Islands					
Samalga and Umnak	207.60	508	1,209	± 207	5.82
Bogoslof	3.48	0	0		0.00
Vsevidof	4.87	0	0		0.00
Ogchul	1.44	0	0		0.00
Kigul	3.84	3	7	± 1	1.86
Adugak	3.04	0	0		0.00
Unalaska	442.71	438	1,043	± 179	2.35
Sedanka	38.40	116	276	± 47	7.19
Egg	3.71	1	2	± 0	0.64
Unalga	18.27	10	24	± 4	1.30

Table 1. continued.

Island Group/ Island Name	Sampled Area (km^2)	Actual Count	Corrected Count	95% c.i.	Density (Otters/km^2)
Akutan	55.63	59	140	± 24	2.48
Akun	57.96	298	709	± 121	12.20
Rootok	8.65	0	0		0.00
Avatanak	20.80	11	26	± 4	1.26
Tigalda	35.88	6	14	± 2	0.40
Ugamak	11.62	2	5	± 1	0.41
Aiktak	3.26	0	0		0.00
Subtotal	**921.16**	**1,458**	**3,470**	**± 594**	**3.75[a]**
Aleutian Islands[b]	**2625.54**	**8,048**	**19,157**	**± 3,281**	**7.28[a]**

[a] Overall denisity

[b] Amchitka estimate for 4/25/92 used in Rat Island subtotal and Aleutian Islands total.

Table 2. Comparison of sea otters from 53 Aleutian Islands from from counts made in 1965 (Kenyon 1969) and 1992. Percentage increases were estimated for those islands with initial population estimates of zero. NS = not surveyed

Island Group/ Island Name	Kenyon (1965)	This Survey (1992)	Percent Difference
Near Islands			
Attu	13	636	+4792
Aggattu	4	216	+5300
Shemya	10	49	+390
Adlaid/Nizki	0	54	+540
Subtotal	**27**	**955**	**+3437**
Rat Islands			
Amchitka	1144	755	-34.00
Buldir	15	11	-26.66
Kiska/Little Kiska	1229	456	-62.89
Segula	56	19	-66.07
Khostov/Davidof/Pyramid	39	41	+5.12
Little Sitkin	135	38	-71.85
Rat	326	79	-75.76
Semisopochnoi	203	62	-69.45
Subtotal	**3147**	**1461**	**-53.57**
Delarof Islands			
Amatignak	70	16	-77.14
Ulak	107	36	-66.35
Unalga	16	6	-62.50
Kavalga	155	95	-38.70
Ogluiga/Skagul	190	123	-35.26
Ilak/Gramp Rock	32	40	+25.00
Gareloi	83	19	-77.10
Tanaga	1059	317	-70.06
Bobrof	32	10	-68.75
Kanaga	1054	333	-68.40
Subtotal	**2798**	**995**	**-64.43**

Table 2. continued.

Island Group/ Island Name	Kenyon (1965)	This Survey (1992)	Percent Difference
Western Andreanof Islands			
Adak	1336	1045	-21.78
Kagalaska	298	157	-47.31
Little Tanaga	509	38	-92.53
Umak	392	38	-90.30
Anagaksik	0	1	+10
Great Sitkin and Nearby Islands	710	170	-76.05
Igitkin	7	36	+414
Chugul	5	23	+360
Tagalak	7	19	+171
Subtotal	**3264**	**1527**	**-53.22**
Eastern Andreanof Islands			
Ikiginak Rock	0	0	0
Oglodak	6	3	-50.00
Kasotochi	NS	5	
Koniuji	NS	0	
Atka	228	1119	+391
Amila	159	425	+167
Seguam	28	10	-64.28
Subtotal	**421**	**1562**	**+271**
Islands of Four Mountains			
Not flown in 1965 by Kenyon. No otters seen during complete survey in 1960 under good survey conditions or the partial survey in 1962.			
Fox Islands			
Samalga/Umnak	9	508	+5544
Unalaska/Sedanka	0	554	+5540
Egg/Unalga	0	11	+110
Akutan	0	59	+590
Akun	0	298	+2980
Rootok	0	0	0
Avatanak	2	11	+450
Tigalda	32	6	-81.25
Ugamak	0	2	+20
Subtotal	**43**	**1449**	**+3269**

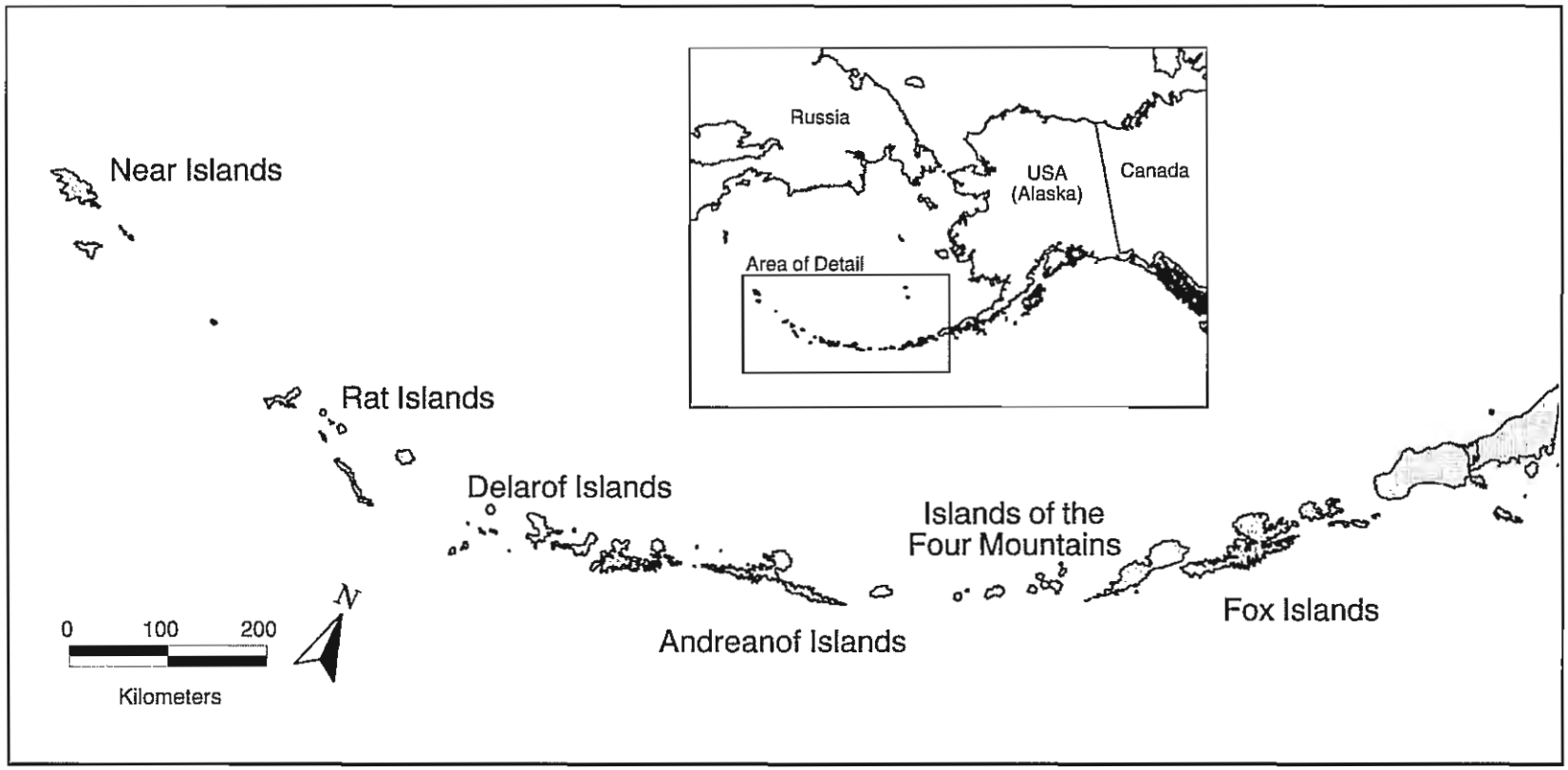

Figure 1. Study area and location of major island groups in the Aleutian Islands, Alaska.

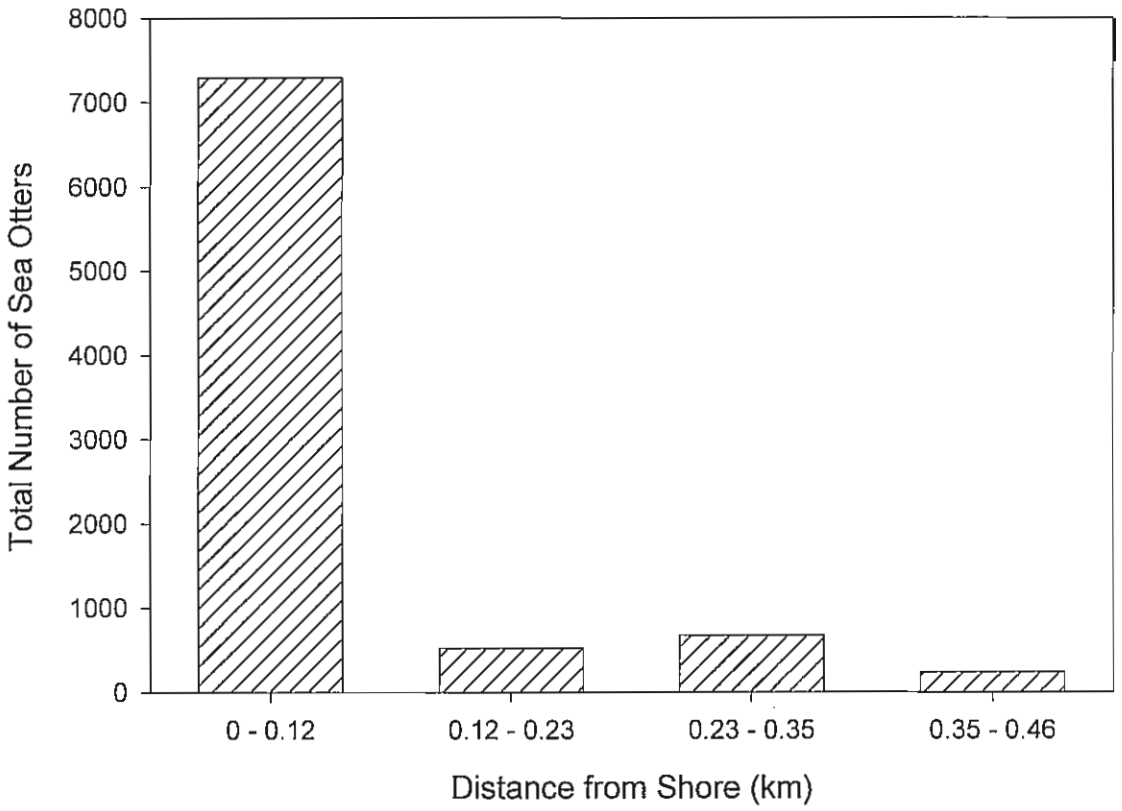

Figure 2. Distribution of distance from shore of sea otters observed during the 1992 aerial survey.

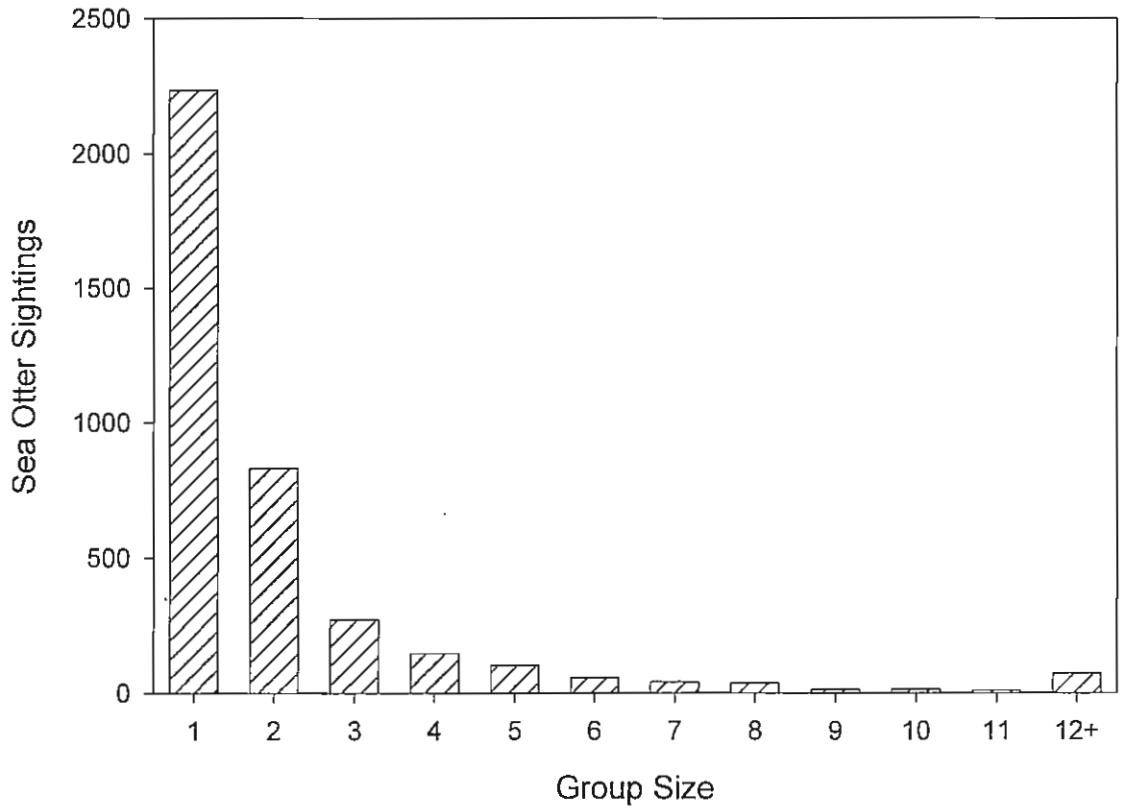

Figure 3. Distribution of group size of sea otters observed during the 1992 aerial survey.

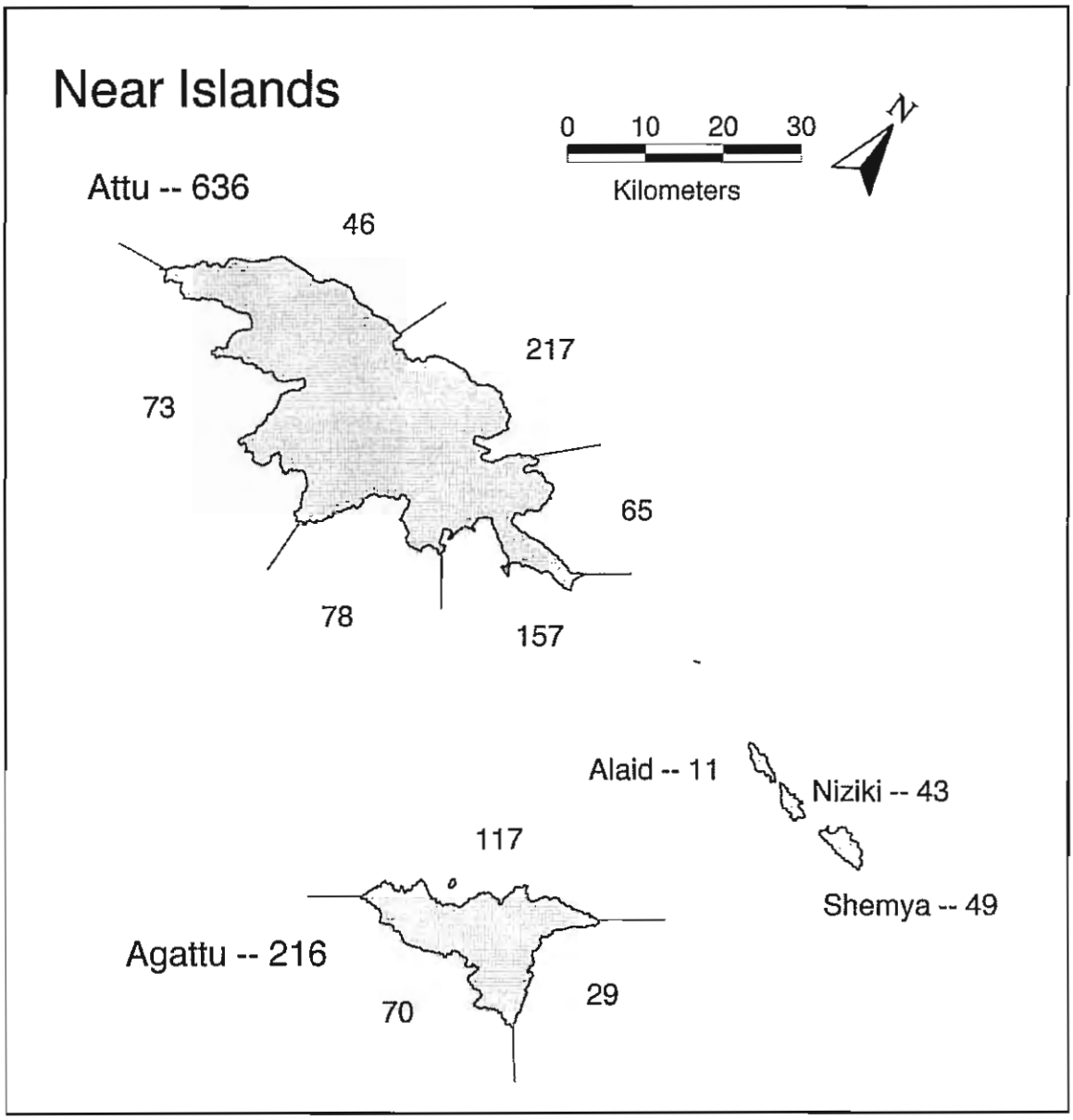

Figure 4. Distribution and abundance of sea otters in the Near Islands observed during the 1992 aerial survey. Numbers represent actual counts.

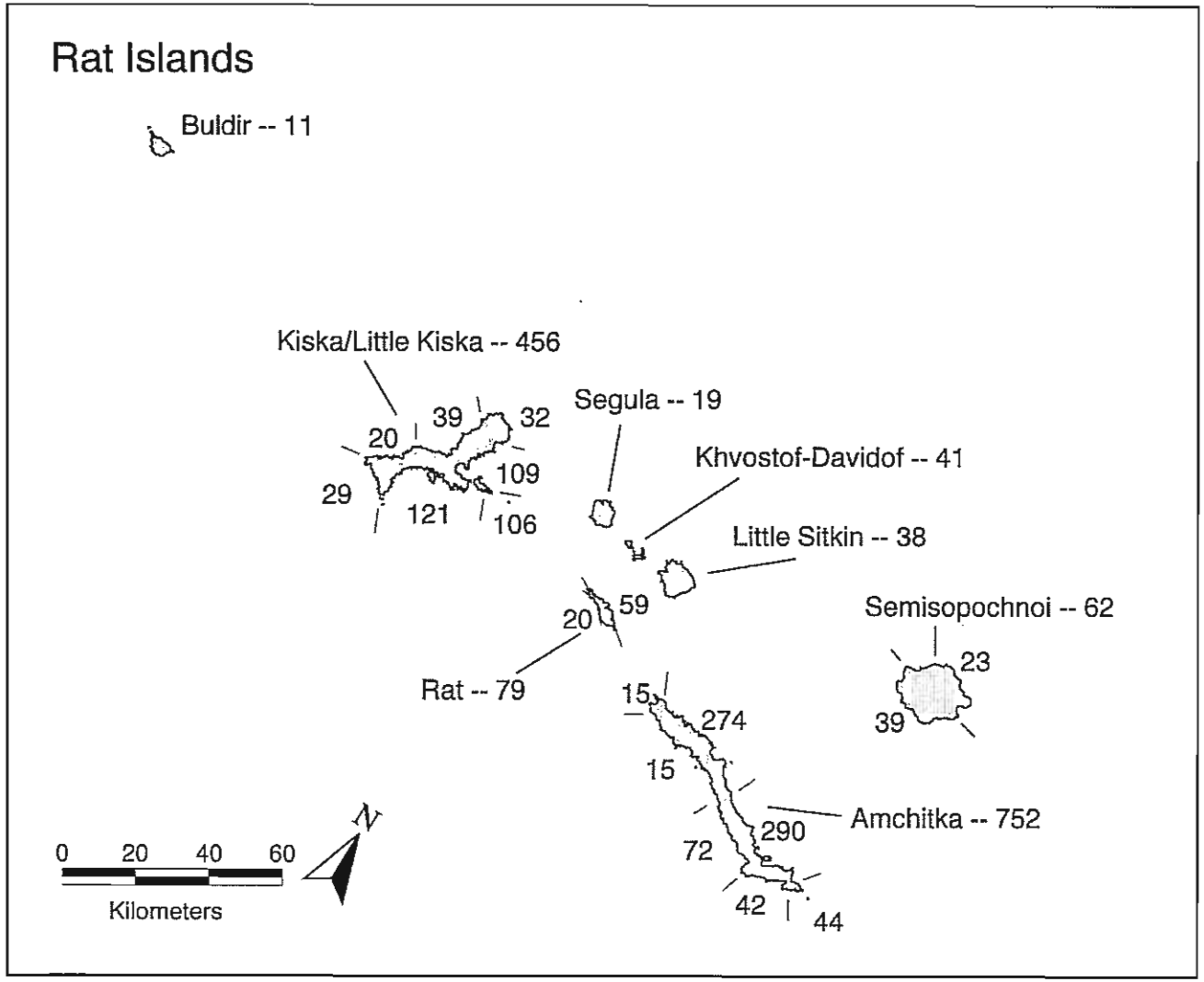

Figure 5. Distribution and abundance of sea otters in the Rat Islands observed during the 1992 aerial survey. Numbers represent actual counts.

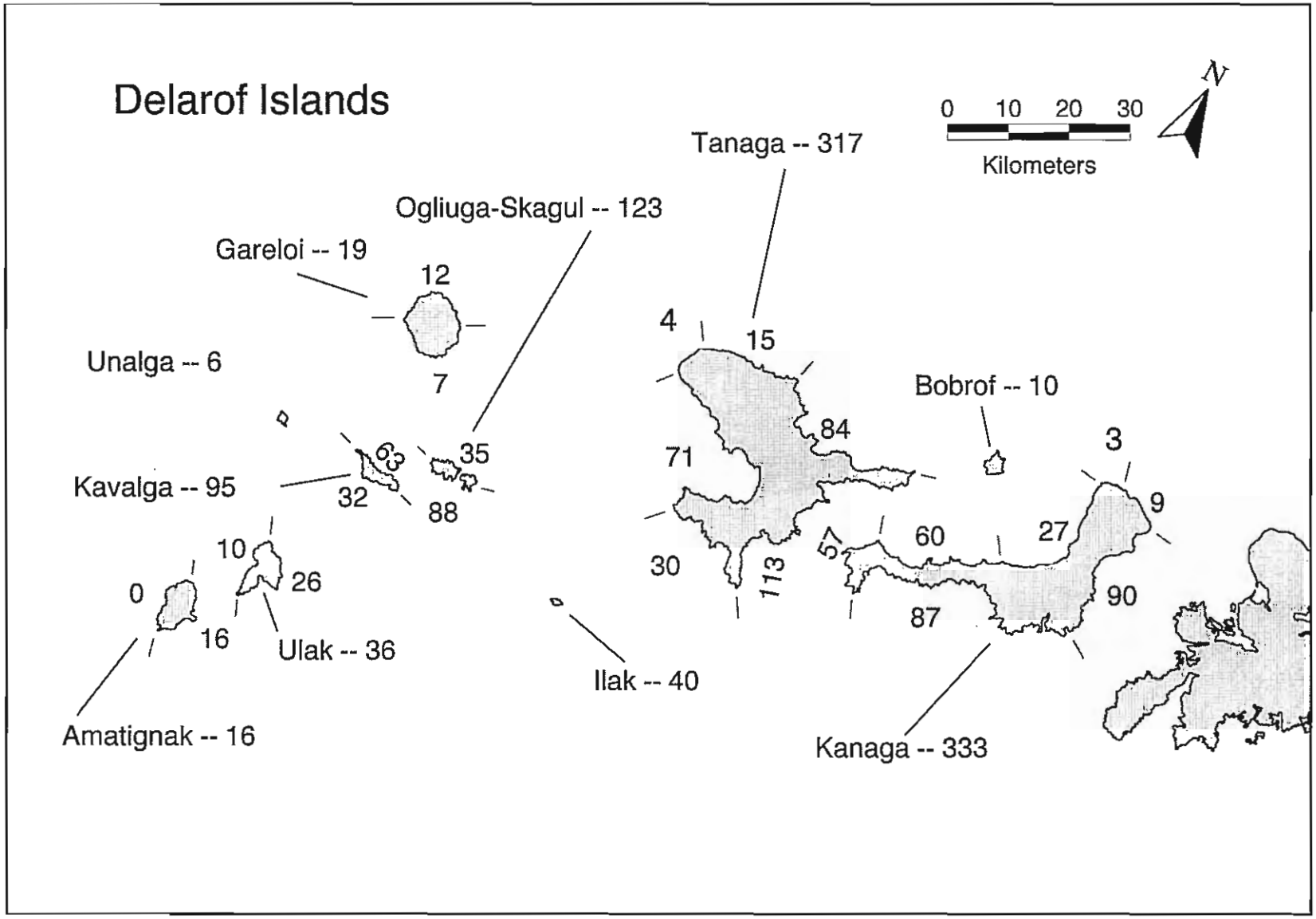

Figure 6. Distribution and abundance of sea otters in the Delarof Islands observed during the 1992 aerial survey. Numbers represent actual counts.

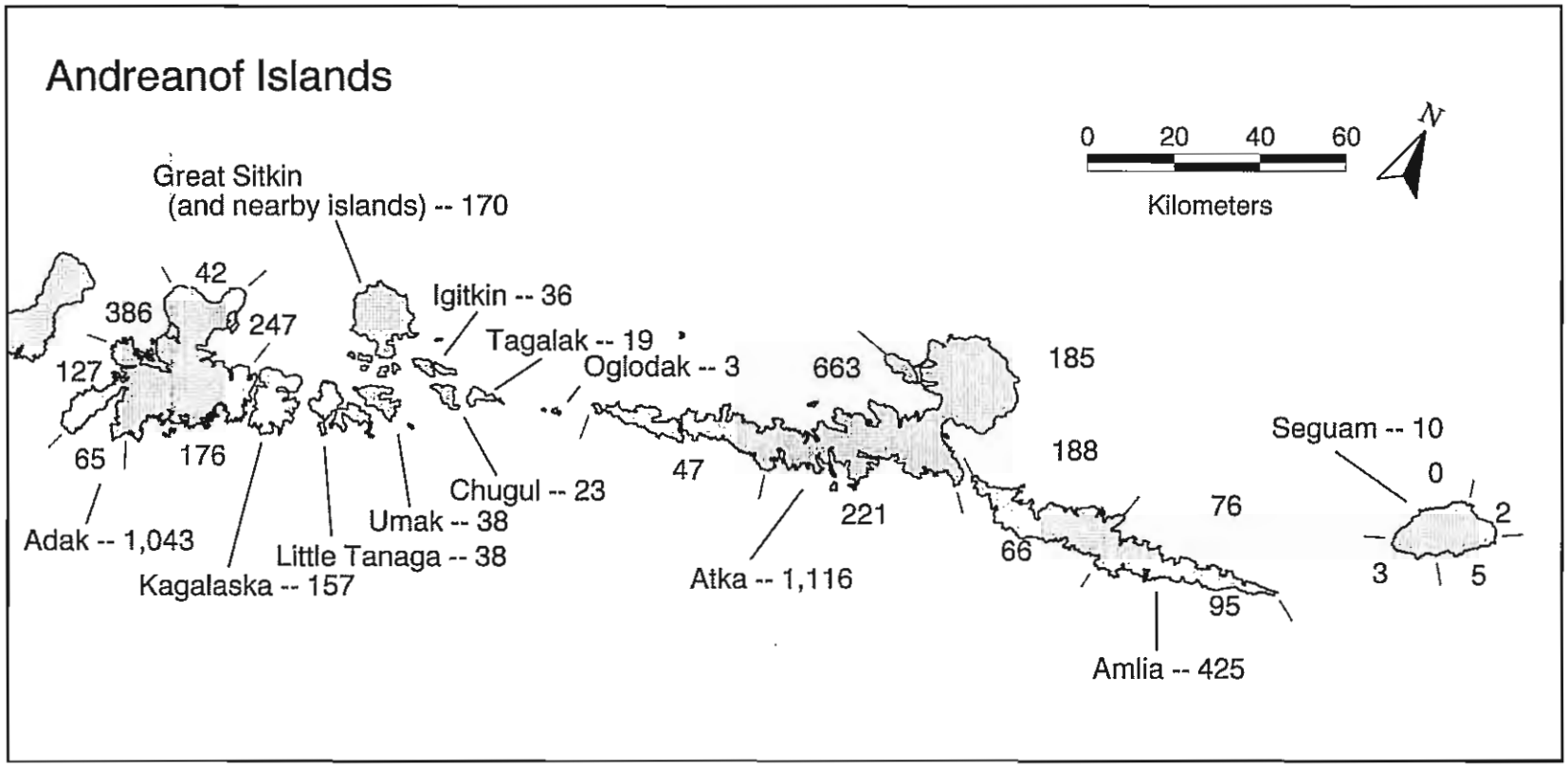

Figure 7. Distribution and abundance of sea otters in the Andreanof Islands observed during the 1992 aerial survey. Numbers represent actual counts.

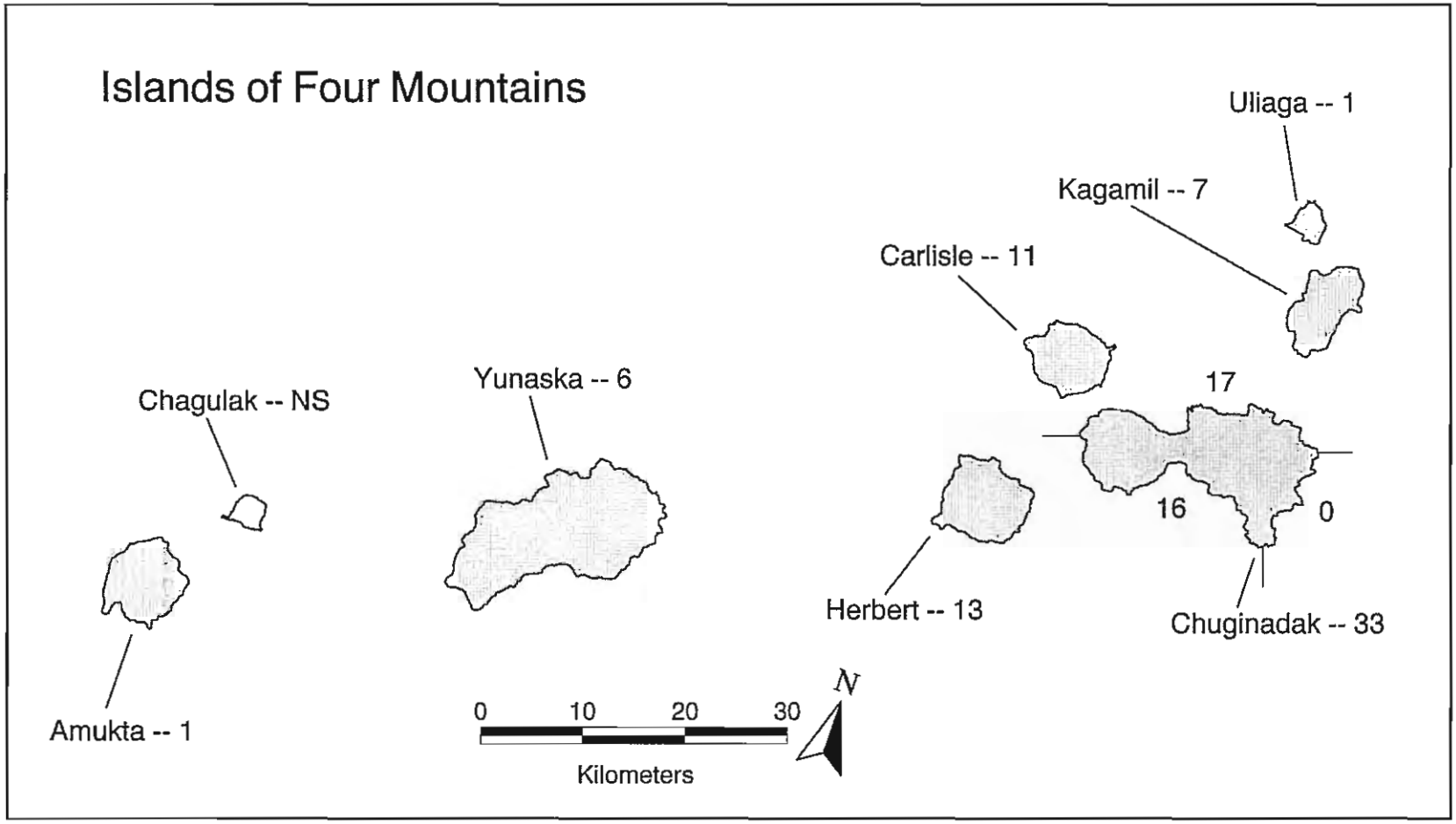

Figure 8. Distribution and abundance of sea otters in the Islands of the Four Mountains observed during the 1992 aerial survey. Numbers represent actual counts.

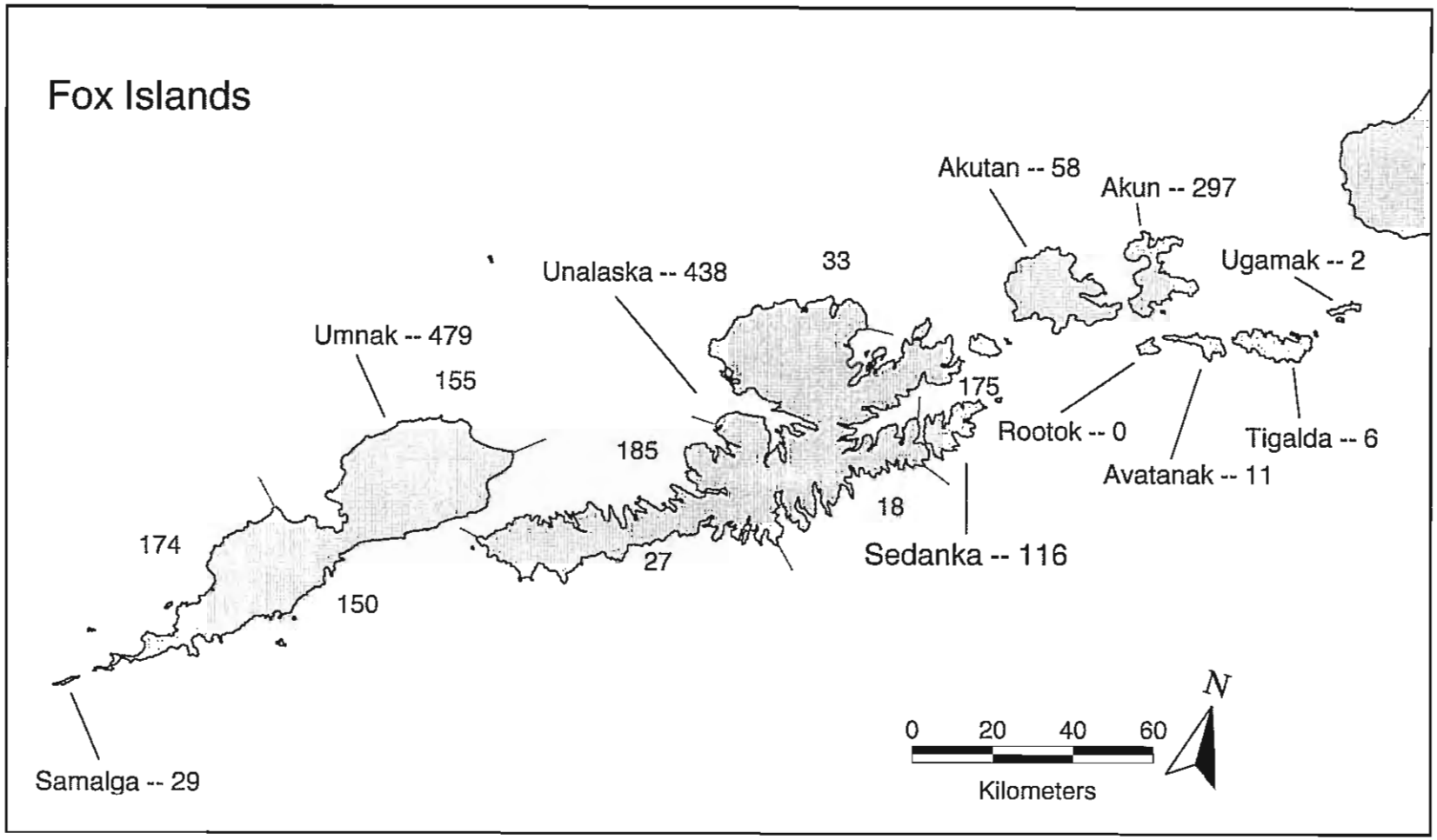

Figure 9. Distribution and abundance of sea otters in the Fox Islands observed during the 1992 aerial survey. Numbers represent actual counts.